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Matrix Transpose Operation

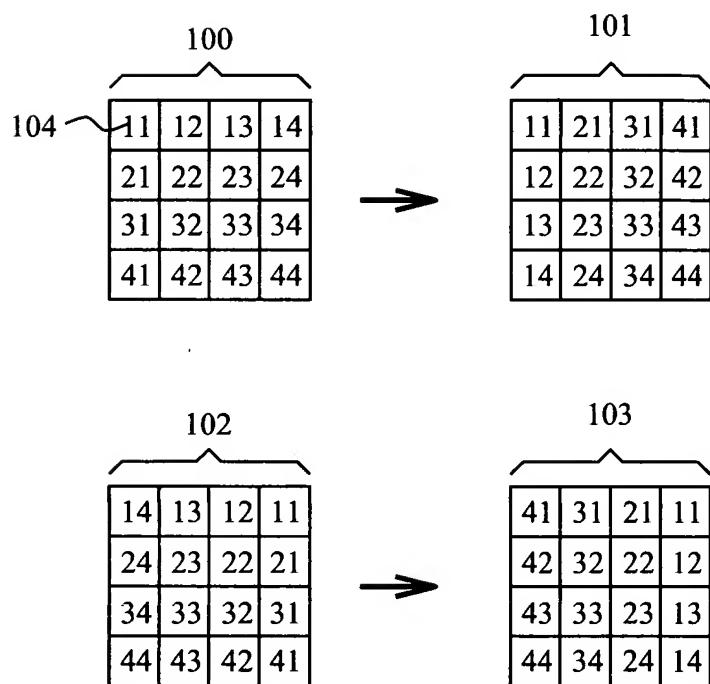


Figure 1

Method for matrix transpose (prior art)

R0 ~	d0	c0	b0	a0	200
R1 ~	d1	c1	b1	a1	
R2 ~	d2	c2	b2	a2	
R3 ~	d3	c3	b3	a3	

$t_0 = \text{Unpack LW R0 R1} =$

b1	b0	a1	a0
----	----	----	----

$t_1 = \text{Unpack LW R2 R3} =$

b3	b2	a3	a2
----	----	----	----

$t_2 = \text{Unpack HW R0 R1} =$

d1	d0	c1	c0
----	----	----	----

$t_3 = \text{Unpack HW R2 R3} =$

d3	d2	c3	c2
----	----	----	----

$V_0 = \text{Unpack LD } t_0 t_1 =$

a3	a2	a1	a0
----	----	----	----

$V_1 = \text{Unpack HD } t_0 t_1 =$

b3	b2	b1	b0
----	----	----	----

$V_2 = \text{Unpack LD } t_2 t_3 =$

c3	c2	c1	c0
----	----	----	----

$V_3 = \text{Unpack HD } t_2 t_3 =$

d3	d2	d1	d0
----	----	----	----

V0 ~	a3	a2	a1	a0	201
V1 ~	b3	b2	b1	b0	
V2 ~	c3	c2	c1	c0	
V3 ~	d3	d2	d1	d0	

Figure 2

Method for Matrix Transpose (prior art)

R0 ~	d0	c0	b0	a0	300
R1 ~	d1	c1	b1	a1	
R2 ~	d2	c2	b2	a2	
R3 ~	d3	c3	b3	a3	

$t_0 = \text{Unpack LW } R_0 R_2 =$

b2	b0	a2	a0
----	----	----	----

$t_1 = \text{Unpack LW } R_1 R_3 =$

b3	b1	a3	a1
----	----	----	----

$t_2 = \text{Unpack HW } R_0 R_2 =$

d2	d0	c2	c0
----	----	----	----

$t_3 = \text{Unpack HW } R_1 R_3 =$

d3	d1	c3	c1
----	----	----	----

$V_0 = \text{Unpack LW } t_0 t_1 =$

a3	a2	a1	a0
----	----	----	----

$V_1 = \text{Unpack HW } t_0 t_1 =$

b3	b2	b1	b0
----	----	----	----

$V_2 = \text{Unpack LW } t_2 t_3 =$

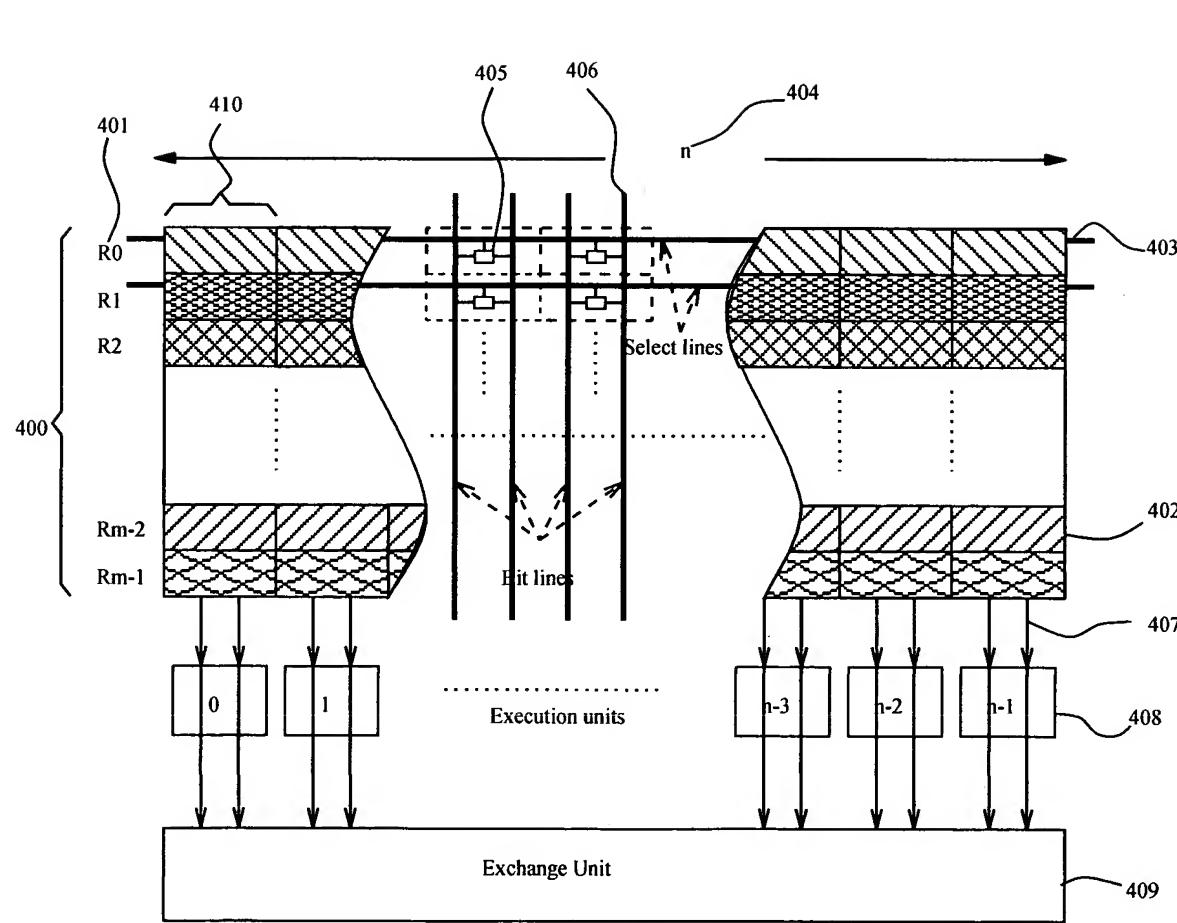
c3	c2	c1	c0
----	----	----	----

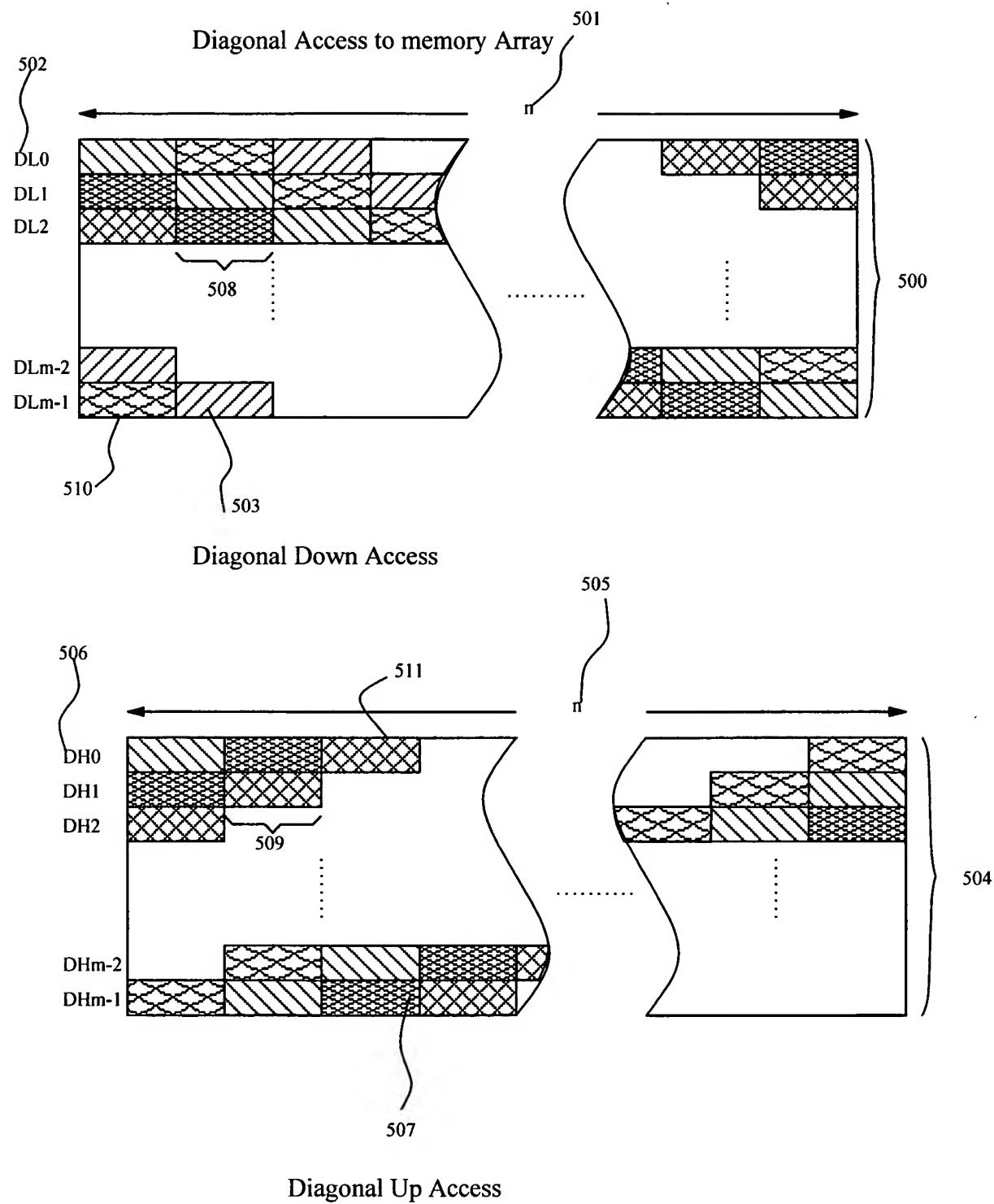
$V_3 = \text{Unpack HW } t_2 t_3 =$

d3	d2	d1	d0
----	----	----	----

V0 ~	a3	a2	a1	a0	301
V1 ~	b3	b2	b1	b0	
V2 ~	c3	c2	c1	c0	
V3 ~	d3	d2	d1	d0	

Figure 3

**Figure 4**

**Figure 5**

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	604							
R0	11	12	13	14	15	16	17	18
R1	21	22	23	24	25	26	27	28
R2	31	32	33	34	35	36	37	38
R3	41	42	43	44	45	46	47	48
R4	51	52	53	54	55	56	57	58
R5	61	62	63	64	65	66	67	68
R6	71	72	73	74	75	76	77	78
R7	81	82	83	84	85	86	87	88

Original Matrix

	601							
DH0	11	22	33	44	55	66	77	88
DH1	21	32	43	54	65	76	87	18
DH2	31	42	53	64	75	86	17	28
DH3	41	52	63	74	85	16	27	38
DH4	51	62	73	84	15	26	37	48
DH5	61	72	83	14	25	36	47	58
DH6	71	82	13	24	35	46	57	68
DH7	81	12	23	34	45	56	67	78

Stage One: Load Diagonal Up

	602							
R0	11	22	33	44	55	66	77	88
R1	18	21	32	43	54	65	76	87
R2	17	28	31	42	53	64	75	86
R3	16	27	38	41	52	63	74	85
R4	15	26	37	48	51	62	73	84
R5	14	25	36	47	58	61	72	83
R6	13	24	35	46	57	68	71	82
R7	12	23	34	45	56	67	78	81

Stage Two: Rotate to the right.

	603							
DL0	11	21	31	41	51	61	71	81
DL1	12	22	32	42	52	62	72	82
DL2	13	23	33	43	53	63	73	83
DL3	14	24	34	44	54	64	74	84
DL4	15	25	35	45	55	65	75	85
DL5	16	26	36	46	56	66	76	86
DL6	17	27	37	47	57	67	77	87
DL7	18	28	38	48	58	68	78	88

Stage Three: Store Using Diagonal Down
Array is Transposed

Figure 6A

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R0	11	12	13	14	15	16	17	18
R1	21	22	23	24	25	26	27	28
R2	31	32	33	34	35	36	37	38
R3	41	42	43	44	45	46	47	48
R4	51	52	53	54	55	56	57	58
R5	61	62	63	64	65	66	67	68
R6	71	72	73	74	75	76	77	78
R7	81	82	83	84	85	86	87	88

605 Original Matrix

DL0	81	12	23	34	45	56	67	78
DL1	71	82	13	24	35	46	57	68
DL2	61	72	83	14	25	36	47	58
DL3	51	62	73	84	15	26	37	48
DL4	41	52	63	74	85	16	27	38
DL5	31	42	53	64	75	86	17	28
DL6	21	32	43	54	65	76	87	18
DL7	11	22	33	44	55	66	77	88

606 Stage One: Load Diagonal Down

R0	12	23	34	45	56	67	78	81
R1	13	24	35	46	57	68	71	82
R2	14	25	36	47	58	61	72	83
R3	15	26	37	48	51	62	73	84
R4	16	27	38	41	52	63	74	85
R5	17	28	31	42	53	64	75	86
R6	18	21	32	43	54	65	76	87
R7	11	22	33	44	55	66	77	88

607 Stage Two: Rotate to the left.

DH0	11	21	31	41	51	61	71	81
DH1	12	22	32	42	52	62	72	82
DH2	13	23	33	43	53	63	73	83
DH3	14	24	34	44	54	64	74	84
DH4	15	25	35	45	55	65	75	85
DH5	16	26	36	46	56	66	76	86
DH6	17	27	37	47	57	67	77	87
DH7	18	28	38	48	58	68	78	88

608 Stage Three: Store Using Diagonal Up
Array is Transposed

Figure 6B

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R0	1	12	13	14	15	16	17	18
R1	21	22	23	24	25	26	27	28
R2	31	32	33	34	35	36	37	38
R3	41	42	43	44	45	46	47	48
R4	51	52	53	54	55	56	57	58
R5	61	62	63	64	65	66	67	68
R6	71	72	73	74	75	76	77	78
R7	81	82	83	84	85	86	87	88

700 Original Matrix

710

0 DH0	11	21	31	41	51	61	71	81
1 DH1	38	48	58	68	78	88	18	28
2 DH2	57	67	77	87	17	27	37	47
3 DH3	76	86	16	26	36	46	56	66
4 DH4	15	25	35	45	55	65	75	85
5 DH5	34	44	54	64	74	84	14	24
6 DH6	53	63	73	83	13	23	33	43
7 DH7	72	82	12	22	32	42	52	62

701

Stage One: Rotate Diagonals DH to the right

711

0 R0	11	21	31	41	51	61	71	81
6 R1	18	28	38	48	58	68	78	88
4 R2	17	27	37	47	57	67	77	87
2 R3	16	26	36	46	56	66	76	86
0 R4	15	25	35	45	55	65	75	85
6 R5	14	24	34	44	54	64	74	84
4 R6	13	23	33	43	53	63	73	83
2 R7	12	22	32	42	52	62	72	82

702

Stage Two: Rotate Rows to the left.

R0	11	21	31	41	51	61	71	81
R1	12	22	32	42	52	62	72	82
R2	13	23	33	43	53	63	73	83
R3	14	24	34	44	54	64	74	84
R4	15	25	35	45	55	65	75	85
R5	16	26	36	46	56	66	76	86
R6	17	27	37	47	57	67	77	87
R7	18	28	38	48	58	68	78	88

703

Stage Three: Swap rows

Array is Transposed

Figure 7